



Open-Ended Problems for Junior High School Students' Mathematical Reasoning

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ABSTRACT

The abilities that must be mastered by high school students according to the demands of the 2013 curriculum include reasoning. Students who have good reasoning abilities make it easier to understand mathematics. But in reality there are still many students who have low mathematical reasoning ability, seen when they have difficulty solving math problems. This research objective is to prove the habit of solving open-ended problems that can improve the mathematical reasoning ability of junior high school students based on the level of initial mathematical ability: high, medium, and low. The study used an experimental method with a "One-Group pre-test post-test design". Randomly, selected 77 grade VII students of SMP Negeri in Bekasi as a sample. The prerequisite test shows that each level of data comes from groups that are normally distributed and homogeneous. The results showed normal gain, both overall and level showed improvement. Based on the t test obtained p value of $0.000 < 0.005$, meaning this study can prove student habits in solving open-ended problems when learning mathematics on triangles and quadrilateral, can improve students' mathematical reasoning abilities.

Keywords: habitation, mathematical reasoning, open-ended problems

ABSTRAK

Kemampuan yang harus dikuasai siswa sekolah menengah sesuai tuntutan Kurikulum 2013 diantaranya adalah penalaran. Siswa yang memiliki kemampuan penalaran yang baik, mudah dalam memahami matematika. Namun kenyataannya masih banyak siswa yang rendah kemampuan penalaran matematikanya, terlihat saat mereka kesulitan menyelesaikan soal-soal matematika. Tujuan penelitian ini untuk membuktikan pembiasaan menyelesaikan soal-soal open-ended dapat meningkatkan kemampuan penalaran matematika siswa SMP berdasarkan level kemampuan awal matematika: tinggi, sedang, dan rendah. Penelitian menggunakan metode eksperimen dengan rancangan "One-Group pre-test post-test design". Secara random, terpilih 77 siswa kelas VII SMP Negeri di Bekasi sebagai sampel. Uji prasyarat menunjukkan data setiap level berasal dari kelompok yang berdistribusi normal dan homogen. Hasil penelitian menunjukkan nilai gain normal, secara level maupun keseluruhan menunjukkan peningkatan. Berdasarkan uji t diperoleh nilai p value $0.000 < 0.005$, berarti penelitian ini dapat membuktikan pembiasaan dalam menyelesaikan soal-soal open-ended saat belajar matematika pada materi segitiga dan segiempat, dapat meningkatkan kemampuan penalaran matematika siswa.

Kata kunci: kemampuan penalaran matematika, pembiasaan, soal-soal open-ended



INTRUDUCTION

The Life skills that can be grown through mathematics learning as stipulated in Ministerial and Cultural (*Permendikbud*) Number 58 of 2016 about concerning Mathematics and Ministerial and Cultural (*Permendikbud*) Number 21 of 2016 about guidelines on content standards including using the ability to think and reason in problem-solving. Thus the importance of reasoning in solving mathematical problems, so that the government made special regulations. Ruseffendi (2006) states that: "mathematics arises because of thoughts related to ideas, processes, and reasoning". The meaning of the statement is that any attempt to understand mathematical knowledge requires reasoning. The reasoning is important in life especially in learning mathematics, because mathematics contains processes that are active, dynamic, and generative (Schoenfeld, 1994). The ability to reason not only makes students able to solve mathematical problems, but the habit of reasoning during school makes students able to solve problems in their lives later (Anisah, Zulkardi & Darmawijoyo, 2011). The importance of having mathematical reasoning abilities in students is in line with the mathematical vision of meeting future needs (Hendriana, Euis & Utari, 2017).

Even though the reasoning is very important in learning mathematics, it is still found, high school students who have low reasoning ability (Linola, Marsitin & Wulandari, 2017; Yuni, Darhim & Turmudi, 2018). Wahyudin (1999) firmly states that if students do not use reason in solving problems, they will fail to master mathematics well. The low reasoning ability of state junior high school students in Bekasi, due to always practicing with questions that are almost the same as the example given by the teacher. Meanwhile, according to the mathematics teacher, the practice is still similar to the example, students have difficulty completing it, especially if given more variety (the results of interviews with several students and mathematics teachers in one of Bekasi State Junior High Schools).

Copi (1978) has been proposed that reasoning is a special thought process with the conclusion taking, and the conclusion is drawn based on the premise/statement. While Keraf (1982) explains reasoning as a thought process connecting known facts to make conclusions. Somewhat different from what was stated by Barrody (1993) and Nasution (2008), mathematical reasoning is very important to help individuals in solving mathematical problems, where reasoning is a skill in estimating based on experience so that learning becomes meaningful learning. If students learn meaningfully, then all knowledge gained will be remembered by students for life. Based on the opinion of some experts, it can be emphasized that reasoning is a thought process that seeks to show the relationship of facts that are known to obtain a conclusion in the form of knowledge that is recognized as truth and has an impact on meaningful learning.

Based on how to make conclusions, Sumarmo (2013) divides reasoning into inductive and deductive reasoning. Inductive reasoning is not only interpreted as concluding specific to general, but meaningful: (1) drawing conclusions based on observations of limited data. (2) the process of concluding based on the possibilities that arise due to premises (Permana & Sumarmo, 2007). So the truth of concluding is not absolute but probabilistic. Hendriana et al., (2017) states that inductive reasoning is divided into 6 types, namely: (1) transductive reasoning; (2) analogy

reasoning; (3) generalization reasoning; (4) estimating answers tend to be on interpolation and extrapolation; (5) provide an explanation; and (6) using patterns or relationships to analyze and construct conjectures. Deductive reasoning is drawing conclusions based on agreed rules (Sumarmo, Hidayat, Zulkarnaen, Hamidah & Sariningsih, 2012). Absolutely the truth value of deductive reasoning is right or wrong, and the two cannot be together. This is a form of thinking whose conclusions appear significantly after obtaining statements. The statements in thought are the premises that produce a conclusion or conclusion. The deduction argument is valid if the premises are true then the conclusion is true. Conversely, the premises are wrong, the conclusions produced are also wrong. This reasoning related to concluding is still low in high school students in Bekasi, especially on indicators: (1) analogy reasoning; (2) generalization reasoning; and (3) using relationship patterns to analyze findings and construct conjectures (Yuni et al., 2018). These three indicators are the focus of an analysis of the reasoning improvement in this study, according to the reasoning ability of grade VII students who are still in the transition phase from elementary school to high school.

The problem of the low ability of mathematical reasoning, especially on the three indicators becomes a serious matter for students and teachers if the solution is not found. Mathematics teachers must use problems that implement mathematics in daily life. Problems relating to daily life are open-ended problems. Open-ended questions that are always given to mathematics learning are more effective in improving the reasoning ability of junior high school students (Melianingsih & Sugiman, 2015). Open-ended questions can train students for understanding problems that are basic abilities, that are very influential for improving students' reasoning abilities (Awaludin, 2008). Furthermore, Mustikasari (2010) revealed that by giving open questions, can provide stimulation to students to improve their way of thinking, students have the freedom to express the results of the exploration of reasoning power and analysis actively and creatively to solve a problem. Learning with open-ended problems will make learning activities more student-oriented (Ariani, Candiasa & Marhaeni, 2014). Students have the opportunity to investigate the various strategies and ways they believe. This will allow students to express their ideas so that their reasoning is trained. The learning phase uses open-ended problems including (1) open-ended problems, students are faced with open problems that have more than one answer or way of solving; (2) constructivism, students find patterns to construct their problems; (3) exploration, conducting exploration activities to find answers; (4) presentation, presenting the results of the answers or findings (Becker & Shimada, 1997).

Mathematical reasoning ability must be familiarized and developed in mathematics learning (Purwaningrum, 2016). The habit of giving mathematical exercises with open-ended problems provides opportunities for students to provide many problems solving with many problem-solving strategies. So with habituation, various answers will be given by students from mathematical problems. Various student answers can detect students' thinking abilities (Ruslan & Santoso, 2013). Because of the variety of students' ways of thinking, the reasoning ability after the treatment of habituation to solve mathematical problems is analyzed based on the initial mathematical ability hereinafter called KAM.

There are three types of open-ended problems generally that can be trained with habituation to improve students' reasoning abilities on the three indicators. The three types of open-ended problems in question are: (1) finding relationships, this problem is given to students so they can find some rules, and mathematical relationships; (2) classifying, aiming that students can classify mathematical problems and solutions based on different characteristics to formulate certain concepts; (3) measurement, students can determine the numerical measurements of a particular event (Sawada, 1997). Based on the preliminary presentation, this study aims to prove that there is an effect of habituation to provide open-ended questions on the subject of triangles and quadrilateral, on improving the mathematical reasoning ability of junior high school students based on KAM, namely high, medium and low KAM group students in Public Junior High School (SMPN) of Bekasi City.

RESEARCH METHOD

This research is an experiment method that using "Quasi-experiment". Because the subject is not being grouped randomly, but already formed as it was (Creswell, 2010; Ruseffendi, 2006; Sugiyono, 2009). We take students of two Junior High Schools as the subject. These subjects did follow the process education, curriculum as usual students from the odd semester, so there is no chance to form group randomly. The other reason why we use this method because objection from the schools where we take the research If we did randomized the students randomly from each class, that's going to disturb the class.

The students that become samples was taken randomly from two of Junior High Schools in sub-district of Bekasi. One from East Bekasi and the other one from North Bekasi. Both schools are ± 19 Km away. The time when we did the research was on even semester of class year 2018/2019. There are 77 students at 7th grade that we took as random sampling. And the process, along the research we did triangular and T square method, with 10 times meet (25 hours of lesson). These 77 students were divided by 3 groups based on their KAM. Then we got 20 students with high KAM, 33 medium, and 24 low.

The instrument that we use to collect the data is using valid and reliable Exam test with 5 ordinal questions. The content or theory we used were consulted with mathematicians, especially in this case with Junior High School teacher and lecturer, and the legibility of the questions or instrument were consulted also by teacher and lecturer Bahasa Indonesia. So these experts said that these questions can be used as instruments of research. We obtained the research data by giving pre-test and post-test. The test is by giving them treatment "get-used-to" with open-ended mathematic questions in worksheet (*Lembar Kerja Siswa* = LKS). And then comparing their pretest and posttest (Creswell, 2010).

The statistic test that being used on the beginning was started Prerequisite test which were Normality test and Homogeneity test, then followed with N-Gain test to see the enhancement from before and after the treatment, and t-test to see the change from these students competence if there are any difference on every level of KAM (high, medium, low) and overall.

RESULTS AND DISCUSSION

Researcher conducted pretest and posttest to seventy seven students were present. Scoring adopts from Jinfa & Jacabcsin (1996) and Sumarmo & Hendriana (2014), the weight of each item varies according to the level of difficulty. The score of each item is in the range of 0-4, so the maximum score is 20. The results of the pretest are grouped on high mathematical reasoning ability (KPM-T), moderate mathematical reasoning ability (KPM-S), low mathematical reasoning ability (KPM-R), and overall mathematical reasoning abilities. Table 1 is the result of students reasoning ability in pretest results based on KAM level.

Table 1. Result Pretest Based on KAM Level

Level KAM	<i>n</i>	Score Min.	Score Max.	Mean
KPM-T	20			5.825
KPM-S	33	0	20	1.736
KPM-R	24			0.619
Totally KPM	77			2.493

The highest score was obtained by students during the pre-test is 9 score, it was 2.6% from the high KAM group. The lowest value is 0, it was 20.8% of the medium and low KAM group. The average score of mathematical ability obtained in each KAM group and overall still does not meet the minimum completeness criteria (KKM), which is a score of 14 (70% from the maximum score).

The material of triangles and rectangles is not new material for VII grade students, because in the previous level they have learned it. So it is not difficult material for VII grade students. But there is additional new knowledge including the number of angles in triangles and rectangles, calculating angles associated with previous knowledge that is the relationship between angles (angular straight, angular, contradictory, contradictory, opposite, inside and outside).

After giving a pretest, it was start applying the habit of completing the exercise with open-ended questions summarized in the worksheets, that has been consulted with experts in this matter with lecturers and mathematics teachers, and declared to be appropriate to use. At first, the students finished on the exercises individually, the learning atmosphere was calm, but not conducive. As can be seen in Figure 1, the high KAM group is more serious and very independent, because they are too focused on solving problems until they do not want to be bothered by friends who ask or borrow something, to turn to the friend next to them is not doing (Figure 1.i). The KAM group was more often whispering, asking questions with my classmates, or the reason for borrowing stationery with friends in front or behind (Figure 1.ii). Whereas in the low KAM group, it was difficult to work on the worksheets so that they expected more help but were embarrassed to express it (Figure 1.iii). Weakness in this this stage, if only practicing alone, students are less motivated, lack self-confidence, still afraid and students are lazy to ask friends or teacher. When asked to some students, they said: "I want to ask questions but I am afraid of being told by stupid friends, I'm not ashamed, ma'am".



Figure 1. First situation while students was finished worksheets with the questions open-ended

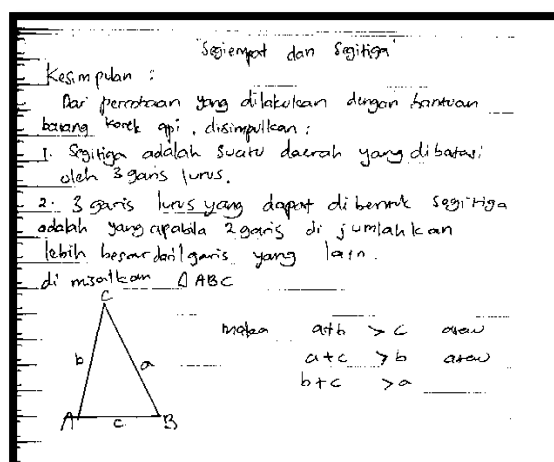
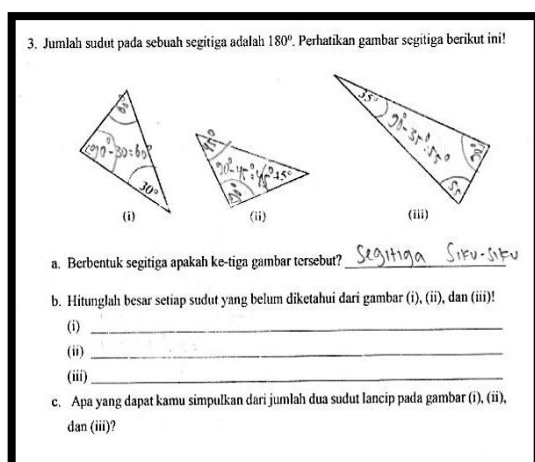
The weakness of the process habituating exercise with open-ended questions at the first to the third meeting, becomes an evaluation to improve the learning process at the next meeting. Indonesian culture which has a high mutual cooperation character inspires researchers to classify students in the next learning process.

The fourth meeting to the seventh meeting made changes, students practice in a cooperative manner. Students are grouped according to KAM, each group consists of 4 students with no regard for gender (shown in Figure 2). By practicing solving math problems in groups, it changes occur in low KAM students, they are more enthusiastic in discussing solving worksheets questions, and start daring to ask friends and teachers if the group does not agree in answering worksheets questions. The high KAM group is still seen working independently, their self-confidence is very high, occasionally seeing each other's work without any discussion. The KAM group is being seen to be more active, not only discussing with my classmates but often interspersed with jokes. The liveliness of the group being more impressed and makes noise. They discuss not only with the group, but with friends who are behind, in front, and also on the side. The teacher becomes more frequent reprimands and reminds them to just discuss with the group. Do not disturb other friends or other groups who are focused on completing worksheets.



Figure 2. Students'situation when they were finished worksheet with open-ended questions in groups

At the fifth meeting, students were seen increase in answer open-ended questions in the worksheet. If the first and second meetings many answers are left blank by students, but at the fifth meeting already dared to answer by giving reasons, the logic of thinking that leads to reason begins to appear, even students dare to make conclusions. Even though in concluding there are still many that are not right. This can be seen in the students' answers in Figure 3 below:



(i) (ii)

Figure 3. Students' answer worksheet in second meeting (i) and fifth meeting (ii)

For the eighth to tenth meeting, students are conditioned by the teacher in the process of solving mathematical problems on students' worksheets in a group way. Each group still consists of 4 students without distinguishing gender. Because it is based on the monitoring of researchers and mathematics teachers as collaborators, the practice has been effective in improving student reasoning and can continue until all material is delivered. After making a habit of completing open-ended questions to students until the tenth meeting, posttest is given with the results in Table 2.

Table 2. Result Posttest Based on KAM Level

Level KAM	N	Score Min.	Score Max.	Mean
KPM_T	20			17.475
KPM_S	33	0	20	11.500
KPM_R	24			4.667
Totally KPM	77			11.188

Posttest data is data on the increase in KPM achieved by students after a training routine by completing open-ended questions. The average score of each KAM level, then the data is was tested for normality using the Kolmogorov-Smirnov test (K-S) and homogeneous testing using the Levene test. Both are prerequisite tests that must be performed, the results of the prerequisite tests in Table 3 below:

Table 3. Recapitulation of Prerequisite Test Results Based on KAM level

Level KAM	N	K-S	Asymp. Sig. (2-tailed)	Information	F	Sig.	Information
High	20	0.613	0.847	Normal	0.431	0.508	Homogeneous
Medium	33	0.792	0.556	Normal	0.874	0.353	Homogeneous
Low	24	0.660	0.776	Normal	3.376	0.083	Homogeneous

The conclusion of the normality test results was seen in the K-S column and the Asymp. Sig. (2-tailed) for all levels of KAM obtained a score of Sig. more than $\alpha = 0.05$. This means that all data at high, medium and low KAM levels are normally distributed, so that it can proceed with homogeneity tests using the Levene test. The test results show that all KAM levels obtained Sig. more than $\alpha = 0.05$. This means that all data meet the requirements to proceed to the hypothesis test using the normal gain test and t test. In order to more clearly see an increase in students' reasoning abilities from pretest to posttest, the diagram in Figure 4 is presented below:

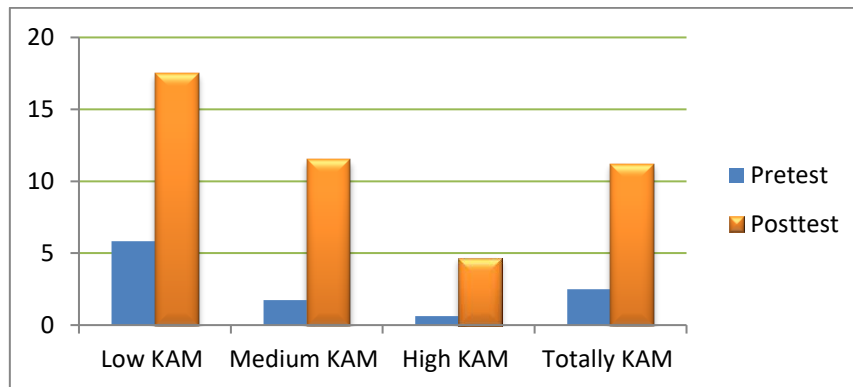


Figure 4. Diagram Result Pretest and Posttest

In Figure 4 the mathematical reasoning ability of the whole group based on KAM was seen increase significantly. Especially the increase in mathematical reasoning in the KAM group is low, it's higher than medium and high KAM.

Because result data of the research comply the prerequisite test, then followed by a hypothesis test using the normalized-gain or N-Gain (g) test aimed at getting an increase in the KPM score of students after it was being given by treatment. The formula for calculating normal gain is:

$$N - Gain = \frac{\text{Score posttest} - \text{score pretest}}{\text{score ideal} - \text{score pretest}}$$

Ideal score is the maximum score that can be obtained, in this research the maximum score is 20. The category of increase can be said to be high if $g > 0.7$; while if it is between $0.3 \leq g \leq 0.7$; and low if $g < 0.3$ (Hake, 2002). The N-Gain data recap is presented in Figure 5.

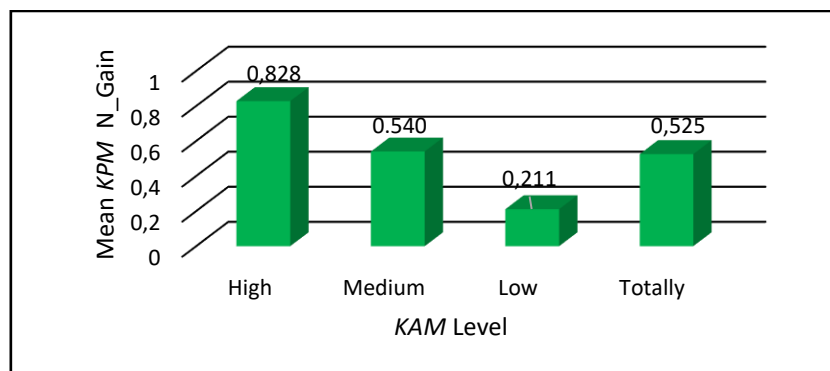


Figure 5. Diagram increasing KPM based on KAM level and Totally

The highest reasoning ability improvement achieved by students at high KAM was 0.828, the increase was classified as high category. Increasing the reasoning ability in KAM is 0.540, the increase is in the medium category. Whereas at low KAM there was an increase in reasoning ability by 0.211, the increase was in the low category. And overall improvement in students' reasoning ability scores 0.525 in the medium category. This means that both in KAM level and overall there is an increase in students' mathematical reasoning abilities through the habit of solving math problems in the form of open-ended questions. The results of this research are in line with the findings of Rohana (2015) who examined the increasing reasoning ability of prospective teacher students by applying reflective learning, where when reflective learning is applied they are always trained with open-ended questions. Reasoning studied by Rohana (2015) includes 5 indicators, it was namely: (1) interpretation of problems based on related concepts, (2) mathematical connections, (3) interesting analogies (4) analyzing and generalizing (5) proof. The findings of this study are not different from the results of Ariani, et al. (2014) about open-ended problems in mathematics learning towards improving problem solving abilities by controlling abstract reasoning abilities, and the research findings of Yuni et al. (2018) by applying IBOE learning (inquiry based on open-ended). Artzt & Yaloz (1999) with problem solving methods.

The N-Gain score is strengthened by the difference test calculated by the t test formula (due to normal and homogeneous data). Recapitulation of t test results in Table 4 below:

Table 4. Recapitulation Result t Test Based on KAM Level and Totally

KAM Level	<i>t</i>	<i>df</i>	Sig. (2-tailed)	α	Information
High	3.931	38	0.0005	0.05	There is difference
Medium	-0.107	64	0.4630		There is no different
Low	-2.18	46	0.0140		There is difference
Totally	7.924	152	0.0000		There is difference

Based on the results of t test, overall there is a difference between pretest and posttest students' mathematical reasoning abilities, this is evidenced by the value of t test = 7,924 and sig. (2-tailed) < α or 0.0005 < 0.05. Likewise for high and low KAM levels, because the value of sig. (2-tailed) < α = 0.05. But for medium KAM level even though the acquisition value of N-Gain is in the medium category, the t test shows there is no difference between the posttest and pretest score. This is indicated by the acquisition of sig. (2-tailed) > α = 0.05 or 0.4630 > 0.05. Why does this happen? Because the amount of the students KAM level groups' medium is higher than the high and low groups, so the guidance and assistance provided by the teacher during the learning process is not optimal, especially in the aspect of time. When students learn with open-ended questions, they are trained and guided to independently "find" the right answers in ways that are more effective and understood. Learning discovery will be effective if students have the ability to think mathematics and a strong willingness to learn (Sanjaya, 2003). The ability to think depends heavily on logic as well as reasoning requires a logical basis. Reasoning in logic is not a process of remembering, memorizing or imagining but is a series of processes looking for other information

and linking it with prior knowledge (Anisah et al., 2011). To carry out all these processes requires a strong willingness to learn (intrinsic motivation) and it can be grown with motivation and habituation from the teacher (Yuni et al., 2018).

The success of discovery learning will also be successful in students with an ideal amount, it means not too little or too much students in classroom. At a high level of KAM, their mathematical thinking ability is no doubt, and the willingness to learn students with high mathematical thinking abilities must be very strong. In KAM level students are low even though their mathematical thinking ability is low, but their learning will not necessarily be low either. This is the basis of the findings in this research, so there are differences in students' mathematical reasoning abilities at high and low KAM levels. Increased reasoning ability after being given a habit of training with open-ended questions at high and low KAM, supported by their ideal number and having a high willingness to learn. Another finding of this research is that students with low KAM are not identical with low learning will.

At the medium KAM level, in this research there was no evidence of differences in mathematical reasoning abilities between pretest and posttest. This is assumed based on the opinion of Sanjaya (2003), their willingness to learn is not as strong as the high and low KAM groups. Because in the learning process there were people than the high and low KAM, it is more difficult to focus and to be independent. Because of their greater amount, guidance is made for groups to be time efficient. Because group guidance, reasons for asking questions or discussions with friends, are used to "chat" things that have nothing to do with the lesson. But these findings require further research.

CONCLUSION

Based on the results of research and discussion, it was concluded that getting used to solving problems with open-ended problems. It can improve the ability of mathematical reasoning based on the KAM level in VII grade students in Bekasi City Middle School on triangles and quadrilateral lesson. The increase occurred at each level of KAM (high, medium and low), there were also differences overall. The best increase is in the low KAM group. Even if there is an increase, the difference in the pretest and posttest scores of mathematical reasoning abilities is not proven at the moderate KAM level. The open-ended questions which are given must be adjusted to the thinking ability of the VII grade students and adjusted to the indicator of the reasoning ability of the VII grade age. Besides they have adequate KAM, the willingness to learn mathematics must also be strong so that they do not have difficulties when participating in learning that applies open-ended problems. In general, the results of this research can convince to the teacher or lecturer to want to apply learning by habit of practicing using open-ended questions in an effort to improve mathematical reasoning abilities.

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